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New records of *Arthoniaceae* from Vietnam

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Abstract—*Arthonia complanata*, *A. elegans*, *A. pyrrhuliza*, *Arthothelium ruanum*, *A. spectabile*, and *Herpothallon minimum* are newly reported from Vietnam. An identification key is provided to the 18 *Arthoniaceae* species known from Vietnam.

Key words—corticolous, lichenized fungi, mangrove, national park, taxonomy

Introduction

The present study was conducted at low (<300 m) elevations of southern Vietnam in two national parks: Nam Cat Tien National Park and Dan Xay Mangrove Park. In addition to several interesting elements in *Graphidaceae*, *Pyrenulaceae*, and *Trypetheliaceae*, the national parks revealed the significant occurrence of arthonioid lichens. The *Arthoniaceae* have been little studied in Vietnam: Aptroot & Sparrius (2006) catalogued seven species, *Arthonia antillarum* (Fée) Nyl., *A. cinnabarina* (DC.)Wallr., *A. cyanea* Müll. Arg., *A. microcephala* Vězda, *Crypthonia mycelioides* (Vain.) Frisch & G. Thor, *Herpothallon rubrocinctum* (Ehrenb.) Aptroot & al., and *Myriostigma candidum* Kremp., together with some doubtful species records. Nguyen & al. (2011) recorded *Arthonia accolens* Stirt., while Joshi & al. (2014, 2015) added *Arthonia diorygmatis* S. Joshi & Upreti, *A. excipienda* (Nyl.) Leight., *A. radiata* (Pers.) Ach., and *Herpothallon sipmanii* Aptroot & al.

Our study presents six new Vietnamese records of corticolous lichenized fungi representing *Arthonia*, *Arthothelium*, and *Herpothallon*. An identification key to the *Arthoniaceae* species known from Vietnam is included.

Materials & methods

Lichen specimens collected in December 2015 were deposited in Korea National Arboretum (KH), Pocheon, South Korea in 2016, and samples were studied in the Lichenology laboratory of CSIR-National Botanical Research Institute, Lucknow, India. The morphology was examined using a MSZ-TR dissecting microscope and a Leica DM 500 compound microscope. The following literature was consulted for the identifications: Willey 1890; Awasthi 1991; Makhija & Patwardhan 1995; Aptroot & Sparrius 2006; Grube 2007; Aptroot & al. 2009; Smith & al. 2009; Bungartz & al. 2013; Frisch & Thor 2010; Nguyen & al. 2011; Joshi & al. 2013, 2014, 2015; Jagadeesh Ram & Sinha 2016; Lee & Hur 2016. Thin layer chromatography (TLC) in solvent system A was performed following Orange & al. (2010). Lugol's solution was used to check amyloidity (I+ or I–). Illustrations were prepared using Corel Draw (ver. 12).

Taxonomy

Arthonia complanata Fée, Essai Crypt. Exot.: 54, 1825 ["1824"]. Pl. 1a

Thallus epiperidermal, pale green to off-white, evanescent, delimited by brownish black prothallus, 50–80 µm thick; photobiont trentepohlioid; medulla partly immersed, white; ascomata immersed to emergent, round, shortly linear, flat to convex, black, epruinose, 0.5–1 × 0.3–0.6 mm; epihymenium brownish, K+ greenish, 10–15 µm high; hymenium hyaline to yellowish, filled with a gel matrix, 80–90 µm high, I+ blue; hypothecium hyaline to yellowish, 20–25 µm; asci 8-spored, 70–80 × 25–30 µm, I+ wine red; ascospores soleiform, hyaline, soon becoming brown, transversely 3–4-septate, with large, undivided upper and lower cells, 20–28 × 7–11 µm, I–.

Chemistry—No chemicals detected with TLC.

Distribution & ecology—This species has a tropical distribution (Willey 1890). In Vietnam, *A. complanata* was growing in small and irregular patches on thick and smooth barked trees in association with *Arthothelium* spp.

Specimen examined: **VIETNAM. Dong Nai Province: Tan Phu district**, Nam Cat Tien National Park, 11°24′20″N 107°17′19″E, alt. 256 m, on bark, 17 December 2015, Hur & Woo VN150021 (KH).

Remarks—Enlarged cells at both the ends of ascospores are characteristic of *Arthonia complanata* and distinguish it from *Arthonia excedens* Nyl., which also differs in producing larger ascospores (30–36 × 10–15 µm; Willey 1890, Lee & Hur 2016). Initially, the Vietnamese sample was wrongly interpreted

as *Arthonia ilicinella* Nyl. based on the smaller ascospore size (18–23 × 7–9 µm) cited in the Smith & al. (2009) description. Subsequent comparison of our sample with the description of *A. ilicinella* provided by Nylander (1867) indicated that the *A. ilicinella* ascospores were larger (21–36 × 8–12 µm).

Arthonia elegans (Ach.) Almq.,
Kongl. Svenska Vetensk. Acad. Handl., n.s., 17(6): 19, 1880. Pl. 1B

Thallus mostly endoperidermal reflecting bark texture, whitish to pale green delimited by dark brown prothallus, 50–80 µm thick; photobiont trentepohlioid; medulla endoperidermal; ascomata linear, irregularly to stellately branched, reddish black, epruinose to reddish brown pruinose near the margins, 1–2 × 0.1–0.2 mm; epihymenium reddish brown, K+ purple-red, 5–10 µm high; hymenium hyaline or pale yellow-reddish with anastomosed paraphysoids in a gel matrix, 25–50 µm high, I+ bluish; hypothecium pale yellow-reddish to brownish, 20–25 µm high; ascus 8-spored, 20–25 × 10–15 µm, I+ bluish; ascospores hyaline, soleiform, transversely 4–5-septate with upper enlarged cell, 10–12 × 3–5 µm, I–.

Chemistry—No lichen substances detected with TLC.

Distribution & ecology—Previously known from temperate Europe (Acharius 1810). In Vietnam, it was collected from smooth barked trees.

Specimen examined: **VIETNAM. Dong Nai Province: Tan Phu district**, Nam Cat Tien National Park, 11°26′40″N 107°24′23″E, alt. 164 m, on bark, 18 December 2015, Hur & Woo VN150264 (KH).

Remarks—*Arthonia elegans,* which is in need of urgent taxonomic revision, has been treated under different concepts by various authors. Acharius (1810) did not provide spore sizes in his type description of *Spiloma elegans*. Almquist (1880) reported 15–18 × 7–8 µm spores (3-septate only), 45 × 22 µm asci, and ochre pruinose ascomata, while Smith & al. (2009) described a different taxon (*A. elegans* sensu auct. brit., non (Ach.) Almq.), citing 14–19 × 4.5–7 µm spores (2–5-septate). Although our Vietnamese specimen has even smaller asci and ascospores, it may be either referred to a very broad concept of *Arthonia elegans* s.l. (with a wide range of ascospore sizes, 10–19 × 3–8 µm) or represent an unnamed new species.

Arthonia pyrrhuliza Nyl., Flora 68: 447, 1885. Pl. 1C

Thallus epiperidermal, whitish grey to off-white, ± rimose, delimited by brownish prothallus, 70–150 µm thick; photobiont trentepohlioid; medulla epiperidermal, white, crystalline; ascomata shortly lirellate, linear to bi- or trifurcate, cracked near margins, reddish brown to brown, 0.5–1 × 0.02–0.05

mm, the decaying or infected discs appear dark brown to black; epihymenium brownish, K+ greenish, 15–20 µm high; hymenium hyaline to yellowish, clear, with anastomosed paraphysoids in a gel matrix, 70–80 µm high, I+ blue; hypothecium indistinct; asci broadly clavate, 8-spored, 60–75 × 30–32 µm, I+ wine red; ascospores hyaline, soleiform, with undivided upper cell, tapering at one end, transversely 4-septate, 30–35 × 10–12 µm, I–.

Chemistry—No chemicals detected with TLC.

Distribution & ecology—This maritime species was previously recorded from North America (Grube 2007). In Vietnam, *A. pyrrhuliza* was collected from mangrove forests on thin and ± rough barked trees, where it was growing together with *A. antillarum*.

Specimens examined: **VIETNAM. Ho Chi Minh City: Can Gio district**, Dan Xay Mangrove Park, alt. 13 m, 10°27′35″N 106°54′16″E, on bark, 21 February 2015, Hur & Woo VN150416, VN150417, VN150418, VN150419B, VN150420, VN150426, VN150427, VN150429, VN150436, VN150439 (KH).

Remarks—Superficially, the species can wrongly be interpreted as *Enterographa* spp., which however has entirely different apothecial anatomy. *Arthonia pyrrhuliza* ascospores have been recorded as 12–15 × 4.5 µm (Willey 1890) and 13–19 × 5–7 µm (Grube 2007); however, Vietnamese material differs in producing significantly larger ascospores, appearing much closer in morphology and ascospore size (25–43 × 10–15 µm) to *Arthonia rubella* (Fée) Nyl., which is otherwise distinguished by its ascospores with undivided and rarely tapered large cells at both ends (Willey 1890; Brodo & al. 2001). Given the contradiction with previous descriptions, it is also possible that our material represents an undescribed species. At this time we choose to refer our Vietnamese specimens to *A. pyrrhuliza,* noting that most parts were infected with some lichenicolous fungus producing a black powdery mass.

Arthothelium ruanum (A. Massal.) Körb., Parerga Lichenol. 3: 263, 1861. Pl. 1d

Thallus endoperidermal, thin, brownish grey to off-white, delimited by dark brown to blackish prothallus, ≤50 µm thick; photobiont trentepohlioid, layer poorly developed, mostly dispersed; medulla indistinct to endoperidermal; ascomata scattered to aggregated, numerous, immersed, irregular to bluntly stellate, brownish black, epruinose, sometimes covered marginally with thalline layer, 0.5–1 mm in diam.; epihymenium dark brown, K+ greenish, 10–15 µm high; hymenium hyaline to brownish, clear, with adglutinate paraphysoids, 50–60 µm high, I+ bluish; hypothecium brown, 20–25 µm high; asci 8-spored, 30–50 × 15–20 µm, I+ wine red; ascospores hyaline, muriform (10–15 transverse septa and 2–4 longitudinal septa), 20–25 × 7–10 µm, I–.

Chemistry—No lichen substances detected in TLC.

Distribution & ecology—*Arthothelium ruanum* occurs in Europe, North America, and Asia (Smith & al. 2009, Joshi & al. 2013). In Vietnam, it was collected from thin- and smooth-barked trees.

Specimen examined: **VIETNAM. Dong Nai Province: Tan Phu district**, Nam Cat Tien National Park, 11°25′19″N 107°25′41″E, alt. 135 m, on bark, 18 December 2015, Hur & Woo VN150290 (KH).

Remarks—*Arthothelium ruanum* has also been treated under *Arthonia* as *A. ruana* A. Massal., following incessant discussions and arguments regarding the diagnostic importance of spore septation. Generic delimitation between *Arthonia* and *Arthothelium* is for the most part based on ascomal development (stromatic vs. solitary), epithecium (persistent vs. eroding), arrangement (loose vs. dense) of interascal filaments, and synchronous vs. irregular ascal development (Coppins & James 1979, Grube & Giralt 1996, Lee & Hur 2016). Until there are more extensive studies and wide acceptance of this generic delimitation, we cautiously refer our Vietnamese specimen to *Arthothelium*.

Arthothelium spectabile A. Massal., Ric. Auton. Lich. Crost.: 54, 1852. Pl. 1e

Thallus endoperidermal, whitish grey to dull grey, delimited by blackish prothallus, 100–170 µm thick, photobiont trentepohlioid, layer distinct, continuous, 60–80 µm thick; medulla endoperidermal; ascomata scattered, immersed, roundish, irregular to shortly elongate, ± flat, black, epruinose, flaking away from the thallus at maturity, 0.5–1 × 0.3–0.5 mm; epihymenium brownish green, K+ greenish, 10–15 µm high; hymenium ± hyaline, inspersed with oil droplets, 80–100 µm high, I+ blue; hypothecium hyaline to yellowish, 20–25 µm high; asci 8-spored, 50–80 × 45–50 µm, I + bluish; ascospores hyaline to brownish in late maturity, muriform (10–15 transverse septa and 2–4 longitudinal septa), 35–40 × 10–15 µm, I–.

Chemistry—No lichen substances detected with TLC.

Distribution & ecology—Cosmopolitan (Makhija & Patwardhan 1995; Smith & al. 2009). In Vietnam, *A. spectabile* was growing luxuriantly in mangrove forests and collected from thick and rough barked trees.

Specimens examined: **VIETNAM. Dong Nai Province: Tan Phu district**, Nam Cat Tien National Park, 11°24′20″N 107°17′19″E, alt. 256 m, on bark, 17 December 2015, Hur & Woo VN150070 (KH); Yak farm, 11°23′10″N 107°21′46″E, alt. 128 m, on bark, 17 December 2015, Hur & Woo VN150149 (KH).

Remarks—The Vietnamese specimens agree well with previous descriptions of *A. spectabile* and differ from the closely related *A. keralense* Makhija & Patw., which has a thicker algal layer (50–150 µm; Makhija & Patwardhan 1995).

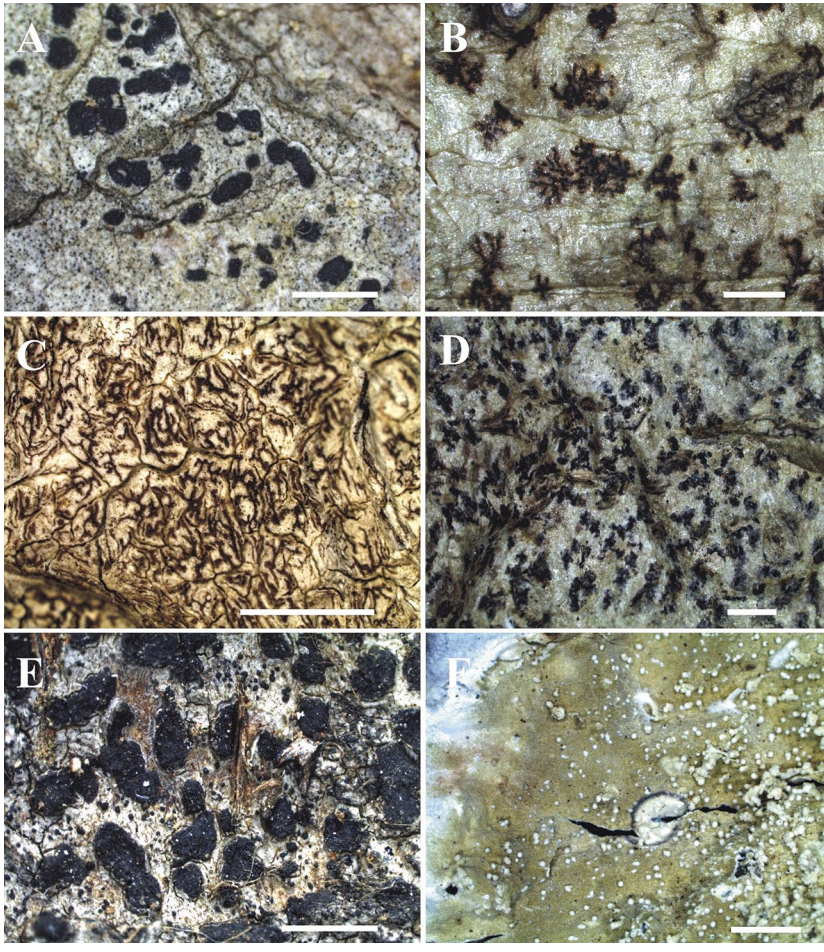

Plate. 1. Arthoniaceous species newly recorded from Vietnam. A. *Arthonia complanata*; B. *Arthonia elegans*; C. *Arthonia pyrrhuliza*; D. *Arthothelium ruanum*; E. *Arthothelium spectabile*; F. *Herpothallon minimum*. Scale bars = 1 mm.

Herpothallon minimum Aptroot & Lücking, Biblioth. Lichenol. 99: 53, 2009. Pl. 1F

Thallus epiperidermal, off-white, pale greenish grey or mineral-grey, ecorticate, sterile, resting on white, byssoid hypothallus, closely adpressed to the substrate, delimited by a broad prothallus of loosely radiating fibrous strands of white hyphae, ≤150 µm thick; abundantly covered with irregular to cylindrical pseudoisidia, ≤0.05 mm long and wide, loose-byssoid, irregular, whitish hypothallus; pycnidia present at the tip of pseudoisidia as black dots.

Chemistry—2′-O-methylperlatolic acid detected with TLC.

Distribution & ecology—Recorded from America and Africa (Aptroot & al. 2009). In Vietnam, *H. minimum* was luxuriantly colonized under shaded trees of seasonal forests in the low-land humid climate of the national park.

Specimens examined: **VIETNAM. Dong Nai Province: Tan Phu district**, Nam Cat Tien National Park, 11°26′43″N 107°24′21″E, alt. 166 m, on bark, 18 December 2015, Hur & Woo VN150269 (KH); 11°26′32″N 107°24′55″E, alt. 151 m, on bark, 19 December 2015, Hur & Woo VN150346, VN150349 (KH); 11°26′60″N 107°21′48″E, alt. 163 m, on bark, 19 December 2015, Hur & Woo VN150395 (KH).

Remarks—The Vietnamese specimens agree well with the type description of *Herpothallon minimum* (Aptroot & al. 2009), but the Vietnamese specimens were initially incorrectly accommodated under *H. granulare* (Sipman) Aptroot & Lücking as a result of their pseudoisidia being misinterpreted as soredia-like granules.

Key to species in *Arthoniaceae* recorded from Vietnam

1. Thallus absent, lichenicolous on *Diorygma*; ascomata dot-like, round, irregular to shortly lirellate, prominent; epihymenium K+ purple, hymenium inspersed (with oil droplets); ascospores hyaline becoming dark brown and warty, 1-septate, 10–16 × 4–5 µm ..... ***Arthonia diorygmatis***
1. Thallus present, non-lichenicolous 2
2. Thallus fertile, byssoid or crustose, ascigerous area organized or not 3
2. Thallus sterile, byssoid, leprose, pseudoisidia present, hypothallus distinct; prothallus made up of radiating hyphae 15
3. Thallus foliicolous or corticolous, byssoid, ecorticate, ascigerous area unorganized, asci closely aggregated in distinctly raised, maculate, flat, ± rounded structures; ascospores muriform, 45–65 × 15–25 µm; 2′-O-methylanziaic and 2′-O-methylperlatolic acids present; hymenium clear or inspersed ..... ***Myriostigma candidum***
3. Thallus crustose; ascigerous area well organized 4
4. Ascospores transversely septate 5
4. Ascospores muriform 14
5. Thallus foliicolous 6
5. Thallus corticolous 8
6. Ascomata black, very small (0.1–0.2 mm diam.), epruinose; ascospores microcephalic, often with one median cell slightly larger, 3-septate (14–16 × 4–5 µm) ..... ***Arthonia microcephala***
6. Ascomata variously coloured, medium-sized to large (0.3–1.0 mm diam.); ascospores macrocephalic, with the distal cell distinctly enlarged, 2–3(–5)-septate 7

7. Ascomata light to dark brown, epruinose, sharply delimited;
ascospores hyaline, 2-septate, 10–16 × 4–5 µm ..... ***Arthonia accolens***

7. Ascomata greenish brown to bluish grey, with a white pruina giving
a bluish appearance; ascospores hyaline to rarely slightly greyish brown,
regularly 2–5-septate, (6–)9–25 × 2–8 µm ..... ***Arthonia cyanea***

8. Ascomata pigmented, ± pruinose, epihymenium K+ purple 9

8. Ascomata unpigmented, epruinose, epihymenium K+ greenish or K– 10

9. Ascomata mostly round to irregular, brown, white pruinose;
margins with cinnabar-red pruina, 0.5–1 × 0.2–0.8 mm;
ascospores hyaline to brown at maturity, transversely 3–5-septate,
15–20 × 7–9 µm ..... ***Arthonia cinnabarina***

9. Ascomata shortly elongate, irregularly to stellately branched, black, epruinose
to reddish brown pruinose near the margins, 1–2 × 0.1–0.2 mm;
ascospores hyaline, transversely 5-septate, 10–12 × 3–5 µm ... ***Arthonia elegans***

10. Ascomata pale brown to reddish brown 11

10. Ascomata black 12

11. Ascomata pale brown, round to irregular, 1–2× 0.5–1 mm;
ascospores hyaline transversely 1–3-septate,
11–17 × 4–7 µm ..... ***Arthonia antillarum***

11. Ascomata reddish brown, shortly elongate, linear, bi- or trifurcate;
ascospores hyaline, transversely 4-septate,
30–35 × 10–12 µm ..... ***Arthonia pyrrhuliza***

12. Ascomata round to irregular; ascospores hyaline to grey-brown at maturity,
transversely 3–4-septate, with large, undivided upper and lower cells,
20–28 × 7–11 µm ..... ***Arthonia complanata***

12. Ascomata substellate or slightly elongate 13

13. Ascomata substellate to irregular, 1–1.5 mm in diam.;
ascospores hyaline to grey brown, transversely 3-septate,
14–16 × 4–5 µm ..... ***Arthonia radiata***

13. Ascomata slightly elongate, often curved or flexuose, occasionally
branched with a slightly raised margin, 1–1.5 × 0.1–0.5 mm;
ascospores hyaline, 1-septate, 20–25 × 8–10 µm ..... ***Arthonia excipienda***

14. Thallus thin, algal layer indistinct; ascomata reddish black, 1–2 mm in diam.;
ascospores hyaline, 20–25 × 7–10 µm ..... ***Arthothelium ruanum***

14. Thallus thick, algal layer ± distinct; ascomata black,
flaking away from the thallus at maturity, 0.5–1 × 0.3–0.5 mm;
ascospores hyaline, soon brownish, 35–40 × 10–15 µm ***Arthothelium spectabile***

15. Thallus pale mineral-grey to green or whitish green,
hypothallus brown; prothallus made up of radiating whitish hyphae;
pseudoisidia disc-shaped (schizidia), pale to off-white,
flattened to slightly convex with round to wavy margin, ≤1 mm diam.;
protocetraric and hypoprotocetraric acids present ..... ***Herpothallon sipmanii***

15. Thallus colour various; pseudoisidia loose or compact, cylindrical to irregular; chemistry lacking protocetraric and hypoprotocetraric acids 16

16. Pigments absent; 2′-O-methylperlatolic acid present . . . . . ***Herpothallon minimum***

16. Pigments (K+ purple) present; lacking 2′-O-methylperlatolic acid 17

17. Thallus greenish grey to greyish orange, rather loose; hypothallus byssoid, brownish to greenish black; prothallus whitish to pale greenish orange; pseudoisidia cylindrical rarely globose, byssoid, concolorous with thallus or strongly pigmented, ≤0.6 mm long and wide; norstictic acid present . . . . . ***Crypthonia mycelioides***

17. Thallus greenish grey to reddish green; hypothallus and prothallus byssoid, deep red; pseudoisidia rather compact and robust, entirely red, 0.5 × 0.4 mm; chiodectonic acid present . . . . . ***Herpothallon rubrocinctum***

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